Methods For Evaluating National Energy Savings (Can we do it?)

LBL Lunchtime Seminar

(based on: *Expanding Evaluation: Impact Analysis for Verifying State and National Commitments to Energy Efficiency*, IEPEC 2009 pre-conference half-day workshop)

IEPEC Workshop Agenda (92 slides)

Part 1: Who's doing what, and why?
- The EU, its ESD, and EMEEES
- The US DOE and EPA
- US regions, states, localities

Part 2: Analysis of current practices
- MC&D
- IPMVP – Option A (monitoring)
- IPMVP – Option C (billing analysis)

Part 3: Exploration of alternatives
- Energy indexes
- Econometric forecasting
- Re-defining "energy savings"

LBL Lunchtime Seminar (28 slides)

Introduction: Who's doing what
- EMEEES Findings
- US, State, Regional, Local
- Definition of energy savings

Proposed new methods
- Re-defining "energy savings
  Econometric forecasting

Critique of old methods
- MC&D
- IPMVP –monitoring
- IPMVP – billing analysis
- Energy indexes

BOTTOM-UP & TOP-DOWN

EMEEES

The project EMEEES deals with the "Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services". The project is carried out by a consortium of 21 European partners and coordinated by the Wuppertal Institute for Climate, Environment and Energy. The EU-funded project (Intelligent Energy Europe) was officially started in November 2006 and runs until April 2009 (EMEEES website).

The ESD (Energy Services Directive) requires that EU Member States increase their use of bottom up energy savings calculations to report on the results of their energy efficiency policies. During the first period the harmonised bottom-up model shall cover between 20 and 30% of the annual energy consumption in a Member State, while from 2012 onwards the further developed model shall cover a significantly higher level of the annual final energy consumption. The European Commission with assistance of the Energy Demand Management Committee develops and improves harmonised methods. These harmonised methods should make the results more comparable over the Member States (Vreuls, 2009).

The Energy Service Directive mentions the need to use so-called "top down methodologies" to assess the ESD target alternatively to bottom-up methodologies (Bosseboeuf, 2009).

EMEEES Summary Findings

BOTTOM-UP

- Provides an explicit evaluation hierarchy based on cost and reliability. Cheapest estimates are the most general and the least reliable, most expensive estimates are most rigorous and most reliable.

- It is implicit that aggregate national-level energy savings ("national policy savings") are calculated as the sum of the bottom-up evaluation**.**

- In the end, the most preferred estimates are those that are derived from one of the 4 IMPVP methods. In other words, US-style impact evaluations are encouraged.

TOP-DOWN

- EMEEES team selected 15 independent variables they called 'energy savings indicators.' A naïve generic regression equation was used to control for factors that contribute to energy savings but are not linked to policies.-- only two effects were considered for possible corrections (1) autonomous trend (2) market price.

- A general conclusion of the econometric analysis carried out to measure the trends and price effects is that the results obtained were not very robust, and the price elasticity or trend were often not significant from a statistical or economic point of view....... the analysis of case studies was quite <u>inconclusive.</u>

Vast majority of USA (Federal, State, Regional, Utility) evaluations

a) MC&D (market counts with deemed savings) evaluation, including logic models, market indicators, market effects

b) IMPVP (monitoring, metering, billing, simulation, persistence of measures, stated preference surveys)

c) Energy efficiency indexes (not currently used – but likely in the near future as it is explicitly mentioned in Waxman-Markey)

Are existing techniques adequate for verifying national policies impacts?

Techniques were created in the 1970's and 1980's to answer this question:

1) **what is average first-year savings for each program?**

These are best answered with bottom-up methods.

But don't we need to answer a different question?

2) **what is total savings every year for all public programs combined?**

IN ESSENCE, THE TWO QUESTIONS IMPLY DIFFERENT DEFINITIONS OF "ENERGY SAVINGS." I CALL Q2

"DEEP SAVINGS"

"deep" in time

"deep" in equipment stock

" deep" in the social fabric

"deep" in behavior

If you believe that the total savings from energy efficiency programs is too insignificant to matter (which was true in the 1970s and 1980s), then for all practical purposes only "conventional savings" matters. But if energy efficiency is viewed as a real resource, then "deep savings" matters more.

8 reasons why average first-year savings *are not the same* as total long-term savings

4 Technological Reasons

1. Measures themselves degrade or fail
2. Measures are removed, replaced, or migrate
3. Physical conditions affecting and interacting with measures change
4. Operations and maintenance of measures change

4 Behavioral Reasons

5. Prices of energy and related goods change how consumers use the measure
6. Income and profit changes change how consumers use the measure
7. Ownership and occupants change, and they have different tastes and needs
8. Public policies change consumer perceptions and behavior

At the very least, to estimate deep savings an evaluation <u>must</u>...

a) control for changes in a consumption that are due to changes in fuel prices, changes in income, changes in the quantity or quality of fuel-using equipment

b) Use a time series to estimate policy impacts spanning at least two or three years

what a national energy efficiency policy evaluation <u>doesn’t have to do</u>...

c) differentiate between policy impacts that come from different programs or measures

d) worry about free riders, spillover, rebound, self-selection

e) worry about general equilibrium effects (changes in employment, non-energy benefits)

Example 1: National-level time series

a) I have a full set of data from 1970 to 2007

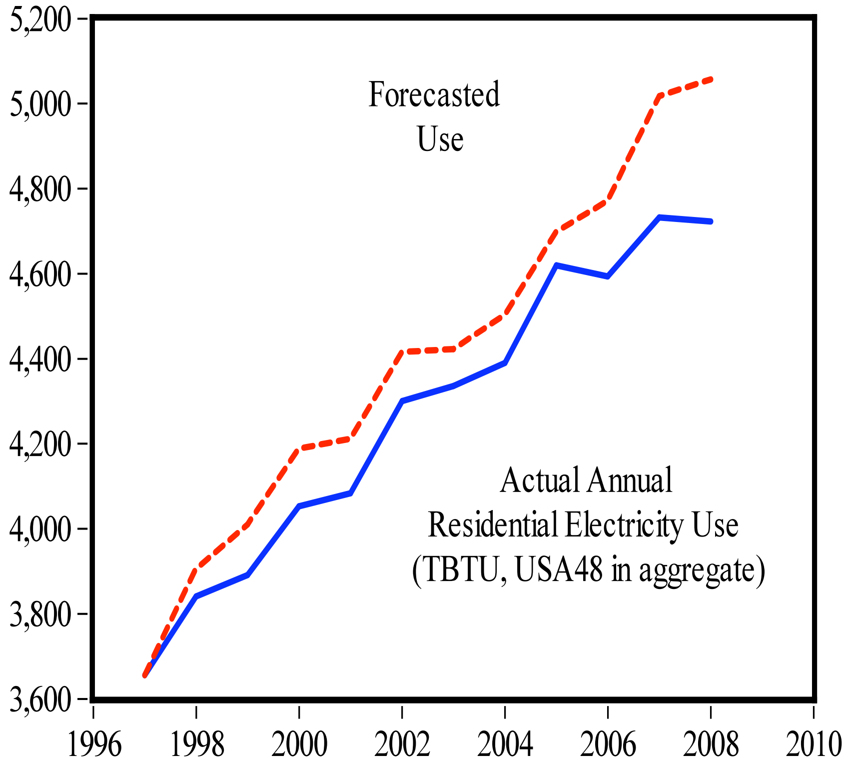
b) I hypothesize that the collective impacts from 1970 to 1997 of all residential energy efficiency programs in the US (aka, "national energy efficiency policy") had the effect of lowering residential energy use from 1998 forward

Dependent Variable: DLOG(ESRB/POP)

Periods included: 27

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(REALESRP)	-0.0689	0.0832	-0.8290	0.4169
DLOG(REALNNRP)	-0.0455	0.0519	-0.8771	0.3909
DLOG(REALPICAP)	0.6614	0.2460	2.6893	0.0141
DLOG(FRBB511)	-0.0381	0.0253	-1.5032	0.1484
DLOG(HDD)	0.1307	0.0520	2.5120	0.0207
DLOG(CDD)	0.1850	0.0377	4.9042	0.0001

Findings: National-level time series



YR	ESRB	ESRBF-USA48
1998	3,841	3,906
1999	3,891	4,010
2000	4,053	4,188
2001	4,084	4,211
2002	4,300	4,415
2003	4,336	4,423
2004	4,390	4,503
2005	4,620	4,698
2006	4,593	4,772
2007	4,732	5,018
2008	4,723	5,057

IMPACTS-06-08

GWH Difference	-233,946
Av. Difference	-77,982
Av. Ann. %change	-5.63%

Example 2: National-level cross section time series

Same data, only now disaggregated by the 48 states

Dependent Variable: DLOG(ESRB/POP)

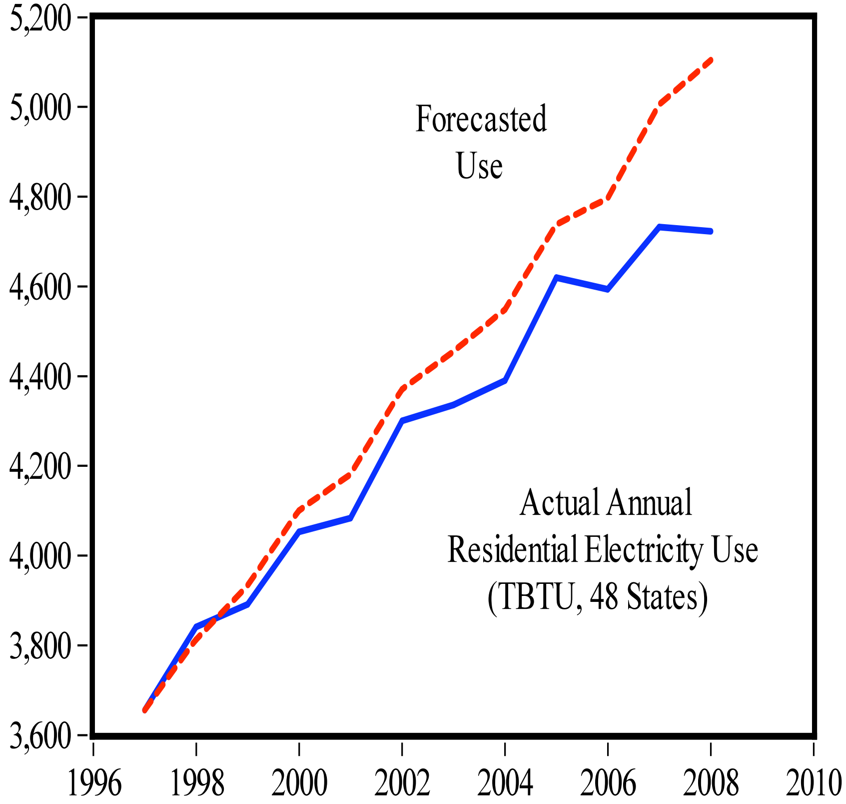
Periods included: 27

Cross-sections included: 48

Total panel (balanced) observations: 1296

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(REALESRP)	-0.1186	0.0190	-6.2451	0.0000
DLOG(REALNNRP)	-0.0110	0.0097	-1.1407	0.2542
DLOG(REALPICAP)	0.2592	0.0405	6.3961	0.0000
DLOG(FRBB511)	-0.0213	0.0068	-3.1229	0.0018
DLOG(HDD)	0.1241	0.0102	12.1079	0.0000
DLOG(CDD)	0.0735	0.0044	16.6545	0.0000

Findings: National-level cross section time series

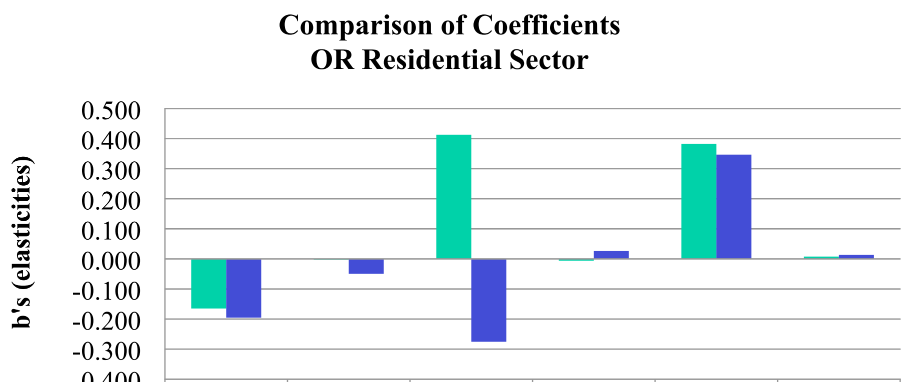


YR	ESRB	ESRBF
1998	3,841	3,812
1999	3,891	3,933
2000	4,053	4,100
2001	4,084	4,181
2002	4,300	4,371
2003	4,336	4,455
2004	4,390	4,549
2005	4,620	4,737
2006	4,593	4,796
2007	4,732	5,005
2008	4,723	5,104
IMPACTS: 2006-2008		
GWH Diff.	-251,024	
Av. Difference	-83,675	
Av. Ann. %change	-6.04%	

Example 3: State-level time series

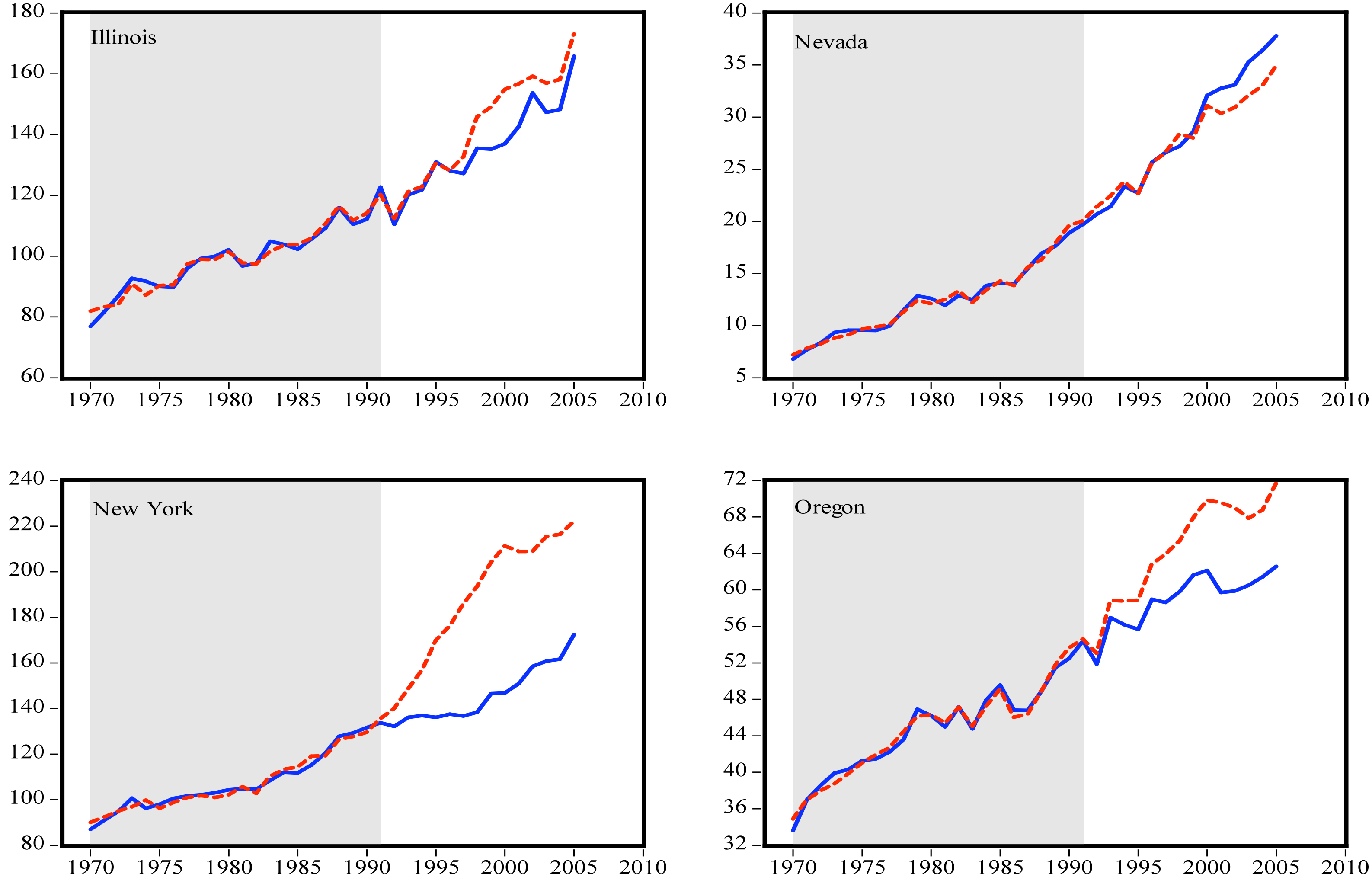
Models for the period from 1970 to 1991 are used to forecast energy use from 1992 to 2005, and also to study behavioral effects of policies

Per Capita kWh	OR Residential Sector	
Fuel	Electricity	
Variables	1970-1991	1992-2005
constant	-8.085	-5.603
s.e.	0.824	1.217
Ele. Price	-0.165	-0.195
s.e.	0.091	0.108
N.G. Price	-0.003	-0.049
s.e.	0.032	0.027
Per Cap. Income	0.413	-0.276
s.e.	0.132	0.475
Tech. Trend	-0.006	0.026
s.e.	0.021	0.047
H.D.D.	0.383	0.347
s.e.	0.068	0.048
C.D.D.	0.008	0.014
s.e.	0.017	0.010
n	22	14
adj. R2	0.73	0.80



	Ele. Price	N.G. Price	Per Cap. Income	Tech. Trend	H.D.D.	C.D.D.
1970-1991	-0.165	-0.003	0.413	-0.006	0.383	0.008
1992-2005	-0.195	-0.049	-0.276	0.026	0.347	0.014

State-level time series policy evaluation:
Total Residential Electricity Use (TBTU), Actual and Predicted



Thumbnail critiques of MC&D, IPMVP, Indexes

1. **MC&D (market counts with deemed savings) evaluation, including logic models, market indicators, market effects are (a) defective in separating volume sold due to supply and demand versus volume sold due to public programs, and (b) use deemed kWh estimates, not empirically estimated kWh**

2. **IMPVP (monitoring, metering, billing, simulation, persistence, stated preference surveys) - SEE BELOW**

3. **Energy efficiency indexes (not currently used – but likely in the near future as explicitly mentioned in Waxman-Markey) - SEE BELOW (and my 2008 paper in EE, "The Trouble with Energy Efficiency Indexes…)**

Complete ex ante formula for calculating gross savings
(no interactions present)

$$CFL\ Program\ Gross\ Savings =$$

$$\begin{bmatrix} (number\ of\ bulbs\ replaced_{pre}) \\ \times (average\ wattage_{pre}) \\ \times (average\ hours\ of\ use_{pre}) \end{bmatrix} - \begin{bmatrix} (number\ of\ CFLs\ installed_{post}) \\ \times (average\ wattage_{post}) \\ \times (average\ hours\ of\ use_{post}) \end{bmatrix} =$$

$$Total\ Energy\ Use_{pre} - Total\ Energy\ Use_{post}$$

Optimistic ex ante gross savings assumptions

Program Planning Assumptions	Existing	Replcd wth
Total Replacemnts	6,000,000	6,000,000
Average Wattage	60	15
Av. Daily Hrs.	3	3
Av. Ann. Hrs.	1,093	1,093
Average Ann. kWh	66	16
Cost per kWh	$0.10	$0.10
Total Annual GWH	393	98
Annual Bill	$39,339,000	$9,834,750
Total GWH Savings	**295**	
Total Bill Savings	**$29.5 M**	

Potential ex post findings

Verification Scenarios	Pre-CFL	Pst-CFL	GWh Savings	Bill Savings
Scenario 1: (all else unchnge)				
Biased Replcmnts	4 M	4 M	197	$19.7 M
Scenario 2: (all else unchngd)				
Biased Pre/ Pst Hrs	2.5	3.5	164	$16.4 M
Scenario 3: (all else unchngd)				
Biased Pre Watts	45	15	197	$19.7 M
Scenario 4: (all combined)				
Biased Replcmnts	4 M	4 M		
Biased Pre Watts	45	15		
Biased Pre/Pst Hrs	2.5	3.5	**66**	**$6.6 M**

MONITORING MAGIC: ERS and Horowitz (1998) for Northeast Utilities

Results from the Lighting Loggers of the 20 On-Sites: Hours Use

	WS	Office	Common	Living Quarters	Cafeteria/Rest	Hallways	Other	Average
Hospital	A1, A2, A3	2,962	1,454	1,654	6,204	6,030	4,652	3,901
	A4			2,940		6,529		3,838
	A9							
	A10							
	Average	2,962	1,454	2,205	6,204	6,130	4,652	3,894
School	A1, A2, A3	1,289				1,374	851	1,054
	A4							
	A9							
	A10							
	Average	1,289				1,374	851	1,054
College/Univ	A1, A2, A3	2,803	5,220		4,096	7,160		3,863
	A4						6,172	6,172
	A9							
	A10							
	Average	2,803	5,220		4,096	7,160	6,172	4,152
Apt/Dorm	A1, A2, A3			5,563				5,563
	A4			485		8,760		2,324
	A9							
	A10							
	Average			1,614		8,760		2,913
Hotel/Motel	A1, A2, A3	2,505	3,816	2,540	5,891	7,058	4,443	3,740
	A4			1,855				1,855
	A9							
	A10		5,975					5,975
	Average	2,505	4,356	2,197	5,891	7,058	4,443	3,557
Office	A1, A2, A3	3,587	3,421		5,488	6,476	3,120	4,289
	A4	6,395	6,655			6,419		6,460
	A9							
	A10							
	Average	3,658	3,734		5,488	6,457	3,120	4,553
Other	A1, A2, A3	1,625	1,611		3,245	6,286	1,991	2,391
	A4							
	A9				3,809		8,759	6,284
	A10							
	Average	1,625	1,611		3,433	6,286	2,241	2,550

20 buildings

153 loggers

7 building types

6 space types

4 lighting technologies

168 cells

42 cells with monitoring

~4 weeks of monitoring

Lighting Hours of Use by Building Type, Worksheet, and Space Type

Building Type	WS	Office	Common	Living Quarters	Cafeteria/Rest	Hallways	Other
Hospital 2	A1, A2, A3	2,962	1,454	1,654	6,204	6,030	4,652
	A4	2,962	1,454	2,940	6,204	6,529	4,652
	A9	2,962	1,454	2,205	6,204	6,130	4,652
	A10	2,962	1,454	2,205	6,204	6,130	4,652
School 3	A1, A2, A3	1,289	1,054	1,054	1,054	1,374	851
	A4	1,289	1,054	1,054	1,054	1,374	851
	A9	1,289	1,054	1,054	1,054	1,374	851
	A10	1,289	1,054	1,054	1,054	1,374	851
College/Univ 4	A1, A2, A3	2,803	5,220	3,863	4,096	7,160	6,172
	A4	2,803	5,220	6,172	4,096	7,160	6,172
	A9	2,803	5,220	4,152	4,096	7,160	6,172
	A10	2,803	5,220	4,152	4,096	7,160	6,172
Apt/Dorm 6	A1, A2, A3	5,563	5,563	5,563	5,563	8,760	5,563
	A4	2,324	2,324	485	2,324	8,760	2,324
	A9	2,913	2,913	1,614	2,913	8,760	2,913
	A10	2,913	2,913	1,614	2,913	8,760	2,913
Hotel/Motel 7	A1, A2, A3	2,505	3,816	2,540	5,891	7,058	4,443
	A4	2,505	4,356	1,855	5,891	7,058	4,443
	A9	2,505	4,356	2,198	5,891	7,058	4,443
	A10	2,505	5,975	2,198	5,891	7,058	4,443
Office 10	A1, A2, A3	3,587	3,421	4,289	5,488	6,476	3,120
	A4	6,395	6,665	6,450	5,488	6,419	3,120
	A9	3,658	3,734	4,553	5,488	6,457	3,120
	A10	3,658	3,734	4,553	5,488	6,457	3,120
Other 12	A1, A2, A3	1,625	1,611	2,391	3,245	6,286	1,991
	A4	1,625	1,611	2,550	3,433	6,286	2,241
	A9	1,625	1,611	6,264	3,809	6,286	8,759
	A10	1,625	1,611	2,550	3,433	6,286	2,241

126 empty cells filled by defaults

1) by space type by building type

2) by technology type by building type

3) by building type

The typical evaluation: light loggers are installed on a sample of CFLs. When the evaluation is complete, the accuracy of the program gross savings should be calculated by the formula:

$$SE(CFL\ Program\ Gross\ \ Savings) =$$

$$\sqrt{\left[Total\ Energy\ Use_{pre} \times \sqrt{\left(\frac{SE(C_1)}{C_1}\right)^2 + \left(\frac{SE(C_2)}{C_2}\right)^2 + \left(\frac{SE(C_3)}{C_3}\right)^2}\right] + \left[Total\ Energy\ Use_{post} \times \sqrt{\left(\frac{SE(C_4)}{C_4}\right)^2 + \left(\frac{SE(C_5)}{C_5}\right)^2 + \left(\frac{SE(C_6)}{C_6}\right)^2}\right]}$$

C_1 = total number of incandescent bulbs replaced
C_2 = average incandescent bulb wattage
C_3 = average annual hours of use, pre-installation
C_4 = total number of CFLs installed/added
C_5 = average CFL wattage, post-installation
C_6 = average annual hours of use, post-installation

... yet, only the standard error of C_6 is reported

NTG factors: Recollections, stated preferences, and cognitive biases

$$\text{Conventional NET SAVING} = NTGFR \times \left[(C_4) \times (\triangle C_5) \times (C_6) \right]$$

If you wanted the full, unbiased CFL program net savings and the full, unbiased standard error of net savings, you would really need all of this information...

$$\begin{aligned}
&\text{CFL Net Program Savings} \\
&= \left[\begin{array}{l} \left[(\text{number of bulbs replaced}_{pre}) \times (\text{average wattage}_{pre}) \times (\text{average hours of use}_{pre}) \right] \\ - \left[(\text{number of CFLs installed}_{post}) \times (\text{average wattage}_{post}) \times (\text{average hours of use}_{post}) \right] \end{array} \right] \\
&- \left[\begin{array}{l} \left[(\text{number of Free Rider bulbs replaced}_{pre}) \times (\text{average wattage}_{pre}) \times (\text{average hours of use}_{pre}) \right] \\ - \left[(\text{number of Free Rider CFLs installed}_{post}) \times (\text{average wattage}_{post}) \times (\text{average hours of use}_{post}) \right] \end{array} \right]
\end{aligned}$$

$$SE(\text{CFL Net Program Savings}) = \sqrt{ \begin{array}{l} \left[\text{Total Energy Use}_{pre} \times \sqrt{\left(\frac{SE(C_1)}{C_1}\right)^2 + \left(\frac{SE(C_2)}{C_2}\right)^2 + \left(\frac{SE(C_3)}{C_3}\right)^2} \right] \\ + \left[\text{Total Energy Use}_{post} \times \sqrt{\left(\frac{SE(C_4)}{C_4}\right)^2 + \left(\frac{SE(C_5)}{C_5}\right)^2 + \left(\frac{SE(C_6)}{C_6}\right)^2} \right] \\ + \left[\text{Total Free Rider Use}_{pre} \times \sqrt{\left(\frac{SE(C_7)}{C_7}\right)^2 + \left(\frac{SE(C_8)}{C_8}\right)^2 + \left(\frac{SE(C_9)}{C_9}\right)^2} \right] \\ + \left[\text{Total Free Rider Use}_{post} \times \sqrt{\left(\frac{SE(C_{10})}{C_{10}}\right)^2 + \left(\frac{SE(C_{11})}{C_{11}}\right)^2 + \left(\frac{SE(C_{12})}{C_{12}}\right)^2} \right] \end{array} }$$

On-site survey ***free rider*** questions

Survey Questionnaire - page 1	T-8 Fluorescent Systems	Compact Fluorescent Lights	High Efficiency Exit Signs	Electronic Ballasts	Occupancy Sensors	Reflectors or Parabolic Fixtures	Premium Efficiency Motors	High Efficiency HVAC
1. Was any portion of the Express Services Rebate Program measure(s) installed prior to participation in the program? 1 - Yes, (if yes, determine % or quantity) 2 - No 3 - Don't Know	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)
2. Did plans to install any part of the measure(s) exist prior to participation in the Express Services Rebate Program? 1 - Yes, (if yes, determine % or quantity) 2 - No 3 - Don't Know	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)	______ (______ qty) or (______ %) (if yes)
3. Assuming that the Express Services rebate had not been available, would you have installed the measure(s) anyway? 1 - Yes, at the same time 2 - Yes, within six months 3 - Yes, 6 mo. - 1 year later 4 - Yes, greater than 1 year 5 - No (skip to question 6, pg 2) 6 - Don't Know								
4. What portion of the measure(s) would you have installed had the rebate not been provided? (determine % or quantity)	______ qty or ______ %	______ qty or ______ %	______ qty or ______ %	______ qty or ______ %	______ qty or ______ %	______ qty or ______ %	______ qty or ______ %	______ qty or ______ %
5. Assuming that the rebate had not been provided, what level of efficiency (relative to the baseline measure) would you have installed? 1 - Same efficiency 2 - Different efficiency - (determine efficiency) 3 - Don't Know	______ *Fixture Code* (______) (only if #2)	______ *Fixture Code* (______) (only if #2)	______ *Fixture Code* (______) (only if #2)	______ *Fixture Code* (______) (only if #2)	______ [redacted]	______	______ (if answer above is #2, use pg. 3 to record motor efficiencies)	______ *EER/SEER* (______) (only if #2)

On site survey ***spillover*** questions

Survey Questionnaire - page 2	T-8 Fluorescent Systems	Compact Fluorescent Lights	High Efficiency Exit Signs	Electronic Ballasts	Occupancy Sensors	Reflectors or Parabolic Fixtures	Premium Efficiency Motors	High Efficiency HVAC	
6. Have you installed other energy efficient equipment (non-Express Services) during or following installation of the rebated measure(s)? 1 - Yes, with incentives from other programs 2 - Yes, no incentives (quantify relative %) 3 - No 4 - Don't Know									
7. Was your participation in the Express Services program a motivating factor in installing any of the measures? 1 - Yes 2 -									
8. Do you have plans to install other energy efficient measures (non-Express Services) during the next year? 1 - Yes, with incentives from other programs 2 - Yes, no incentives (quantify relative %) 3 - No 4 - Don't Know									
9. Has the Express Services Program affected your decision making regarding energy efficient equipment? 1 - Yes, considerably 2 - Yes, moderately 3 - Yes, minimally 4 - No, has not affected my decisions 5 - Don't Know									

The problem of measure retention (persistence)

Measure retention studies are too expensive to be done often and for every program.

CALMAC lists over 70 retention studies, mostly for 1994-1996 program years. This is a drop in the bucket.

If CA implemented 200 programs every year since 1994 forward, and each installation is assumed to have a 6 year life...

LIFETIME OF SAVINGS = 6 YEARS		
YR	**1st yr Evaluation**	**Retention Study every 3 yrs**
1994	200	0
1995	200	0
1996	200	0
1997	200	200
1998	200	200
1999	200	200
2000	200	400
2001	200	400
2002	200	400
2003	200	400
2004	200	400
2005	200	400
2006	200	400
TOTAL # Evals. thru 2006	**2,600**	**3,400**

Billing analysis (whole building) of tankless NG water heaters

- Despite sample sculpting, non-participants were not comparable. Their baseload use (hot water, cooking, etc.) was 55% higher than that of participants. This clearly means that participants were self-selected – they tend to be low baseload natural gas users to begin with.

PARTICIPANTS

Dependent Variable: AVGREAD

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	$\boxed{0.445}$	0.016	27.088	0.000
AVGHDD	0.158	0.002	64.861	0.000

NON-PARTICIPANTS

Dependent Variable: AVGREAD

C	$\boxed{0.689}$	0.009	73.351	0.000
AVGHDD	0.157	0.001	131.741	0.000

Impact findings

- In addition to discovering that the nonparticipants sample was invalid, I discovered that using heating months for analyzing participant bills confounded the evaluation.

- Below are the final results (based on regression modeling):

Ex Ante (Expected) Savings -- Therms per Year	= 102
Savings using Participants, Only & All Periods	= 31
Savings using Participants and No-Heating Periods, Only	= 55
Gross Realization Rate (Participants and No-Heating, Only)	= 54%

Pinpointing the index problem

$$\left(\frac{(E_1+F_1+G_1)-(E'_1+F'_1+G'_1)}{E_1+F_1+G_1}\right) \neq \left(\begin{array}{l} \left[\left(\frac{E_1}{P_1}\Big/\frac{E_0}{P_0}\right)\times\left(\frac{E_1}{E_1+F_1+G_1}\right)\right] \\ +\left[\left(\frac{F_1}{Q_1}\Big/\frac{F_0}{Q_0}\right)\times\left(\frac{F_1}{E_1+F_1+G_1}\right)\right] \\ +\left[\left(\frac{G_1}{R_1}\Big/\frac{G_0}{R_0}\right)\times\left(\frac{G_1}{E_1+F_1+G_1}\right)\right] \end{array}\right)-1$$

Conventional impact calculation

EE index impact calculation

What national verification findings will look like if they are not analyzed econometrically